ISOTOPIC CONSTRAINS ON DIFFERENTIATION AND EVOLUTION OF SNC METEORITES. E. Jagoutz (Max Planck Institut für Chemie, Postfach 3060, D-55020 Mainz, Germany, E-Mail jagoutz@mpch-mainz.mpg.de).

New isotopic data measured especially on EETA 79001 and Chassigny permit a considerable refinement in the evolution model of SNC meteorites. From the examination of the Rb-Sr, Sm-Nd and the U-Pb isotope systematic we must conclude that only two differentiation processes dominated the evolution of the SNC meteorites. The first and primary differentiation occurred 4.5 Ga ago, the second between 150 Ma and 1.4 Ga. The first differentiation formed chemically distinctive reservoirs from primary accreted material. Those reservoirs might further be called planetary reservoirs. The second differentiation process mainly created the final chemical and mineralogical composition of the SNC meteorites as they are today.

The isotope data were calculated to the present day value and the effect of the second differentiation was corrected out to obtain a comparable set of data for modelling the primary differentiation. For ALHA 84001 the present day isotope values are taken considering that this meteorite did not experience a second differentiation while all the other SNC's must be corrected.

Sr correction: The Sr isotopes of all SNC meteorites plot close to the 4.5 Ga chondritic isochrone. The intercept of the internal Rb/Sr isochrone and the chondritic isochrone is taken as the today's Sr isotopic composition and $^{87}Rb/^{86}Sr$ ratio of the planetary reservoir from which the specific SNC meteorite was contrived by the second differentiation.

U-Pb correction: Whitlokite is the host phase for U and Th. All radiogenic Pb produced since the second differentiation event resides therefore in the whitlokite. Since whitlokite dissolves in HCl, the Pb isotopes of the acid leached residues is a first estimate for the source. Indeed, the Pb isotopes of the SNC meteorite residues plot close to the geochron. The intercept of the internal (leached - residue) isochrone and the geochron were calculated. This might represent the Pb isotopic composition and U/ Pb ratio of the planetary reservoir.

Nd correction: In contrast to the Pb and Sr isotopes which are close to the chondritic evolution, the Nd isotopes of the SNC meteorites show dramatic deviations from the chondritic evolution. The evolution path was extrapolated to the present to assess the present day Nd isotopic composition of the planetary reservoir.

The primary differentiation: The Sr and Nd isotopes plot with a clear negative trend (fig.1). While ALHA 84001 and EETA plots outside this trend, this will be discussed later. There is a common hypothesis that the Sm/Nd ratio of the accreting matter was chondritic. Therefore we are able to interpolate the present day Sr isotopic composition of the average accreting matter using Sr- Nd isotopic correlation. In plot 2 the $^{87}Rb/^{86}Sr$ and $^{147}Sm/^{144}Nd$ ratios of the primary matter are illustrated by the field “Chondrites”. The evolution path of the melt and the residuum at different degrees of partial melting was calculated. The residue moves along the track indicated as “residuum evolution” and the composition of the melt is indicated by ”melt evolution”. The first increment of melt having a high Rb/Sr ratio will move like the residue mainly in the direction of lower Rb/Sr ratio with increasing partial melting (note: the $^{87}Rb/^{86}Sr$ scale is logarithmic!). A higher degree of partial melting will also move the residue to higher Sm/Nd, while the melt gets closer to the primary composition. The melt will reach the primary composition at high degree of partial melting. After 4.5 Ga this chemical change will be reflected in the Sr and Nd isotopes. These isotopic compositions are indicated in fig.1. There is a surprising agreement in the isotopes with the result of a simple melting model. EETH and ALHA 86001 are out of this magmatic trend, but both of these meteorites show evidence of hydrothermal activity. Rb-Sr and Sm-Nd seem to follow a magmatic fractionation trend but U-Th-Pb fractionation seems to be independent from this fractionation. Sr-Nd-Pb isotopes are plotted in a tree dimensional plot (not shown here). The Sr-Nd correlation as seen in fig1 are noticeable and there is a scatter in Pb direction. All data form a plane. This plane is perpendicular to the Sr-Nd correlation (Sr-Nd plane), indicating that the U Pb fractionation was independent from the fractionation which caused the Sr-Nd correlation.

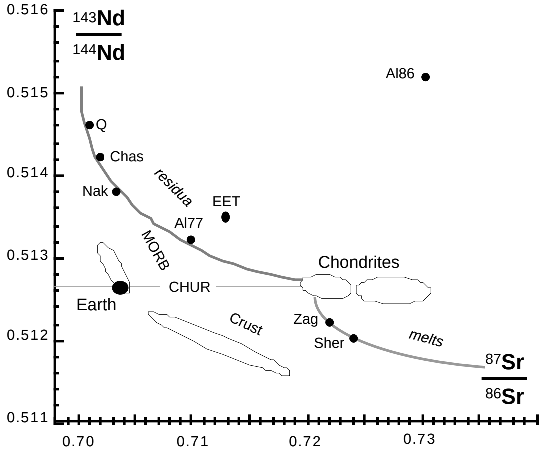

fig. 1

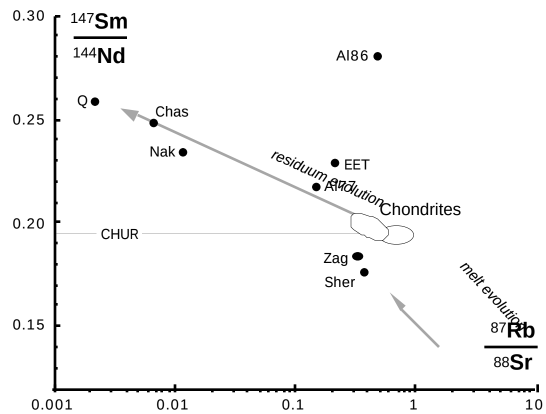

fig. 2

The second differentiation: Details of the second differentiation process will be given. While the first differentiation follows the pattern of a partial melting the second differentiation cannot be explained by any melting processes. While major elements and the modal composition still reflect the trend of the first differentiation, the second differentiation mainly isotopically reset the minerals, but the chemical changes in the whole rocks are not consistent with a melting process. Especially the Rb-Sr but also the U-Pb systematics are not much affected by the second differentiation at all. Most meteorites have excess Pb with respect to U. The SNC meteorites, however are the only meteorites having excess U with respect to Pb. Moreover, the initial Pb is close to the geochron, which is not expected if the excess U existed for a long time. The gain of U (or loss of Pb) might be caused by the second differentiation. The Sm-Nd system is drastically changed by the second differentiation.

There is a temptation to see the secondary differentiation as an internal resetting of the isotopes. However there is a drastic change in the total rock Sm/Nd ratio by the second differentiation as well. In Nakhla and Chassigny (the most depleted residues) the Sm/Nd was decreased, while in the shergotites and lherzolitic shergotites the Sm/Nd ratio was increased. There is no magmatic evolution which can explain these changes without much changing the Rb-Sr system. A suggestion to understand the chemical changes of the second differentiation: a disperse trace mineral with highly fractionated REE and low Sr/Nd ratio was equilibrated to the surrounding minerals and then mobilized out of the sample. Inhomogeneities found in different whole rock splits of the SNC meteorites could also point in this direction.